SHORT CRUISE REPORT R/V METEOR cruise M74/2

Dates: 07.10.2007 (Fujairah) - 28.10.2007 (Fujairah)
Chief Scientist: Prof. Dr. Volkhard Spiess
Institutions:

RCOM: Research Center Ocean Margins, University Bremen, Germany
NOCS: National Oceanographic Centre Southampton, UK
MPI: Max-Planck-Institut für Marine Mikrobiologie, Bremen, Germany
AWI: Alfred Wegener Institute for Polar and Marine Research, Germany
NIO: National Institute of Oceanography, Karachi, Pakistan

Objectives:
The main objectives during M74-2 were to identify and locate active seepage on the Makran accretionary margin offshore Pakistan as well as to understand the role of the Oxygen Minimum Zone (OMZ) in various nutrient cycles and reduction processes. Multi-frequency geophysical profiling - a simultaneously acquired bathymetric, parametric sediment echosounder, deep-tow side scan sonar, and multichannel seismic dataset - was used to find sites of active and potential fluid and gas flux from the subsurface to the surface. The investigations were based on one hand on the morphology and acoustic properties of the seafloor, which reveal consequences of venting in form of precipitates or typical communities of living organisms. On the other hand, the structure and physical characteristics of the subsurface were imaged in order to identify targets such as shallow gas reservoirs or tectonic fluid pathways. These investigations allowed a detailed ROV-based sampling of seepage-related locations during the subsequent cruise leg and contributed to understanding the effect of a unique tectonic setting on margin dewatering and degassing processes.
Within the OMZ, the water column, sediment-water interface, and the shallow subsurface were sampled with the help of newly contrived measuring and sampling techniques, in order to identify influence of low oxygen and methane content on microbial activity.

Cruise narrative:
R/V Meteor arrived to Fujairah in the United Arab Emirates on October 4, 2007. Preparatory work such as mob/demob of the TOBI deep-tow side scan sonar and the planning of optimal usage of deck space started immediately as several large systems were to operate simultaneously in a practicable and safe way. Progress in port was somewhat hindered by the special circumstances due to the Ramadan festivities but eventually and with the personal commitment of the shipping agent, all equipment was safely delivered to the ship. METEOR weighed anchor in the afternoon of October 7 and took to a 30-hour transit to the working area offshore Pakistan. The scientific crew consisted of German, British, Irish, Pakistani, Chinese, Brazilian and Hungarian colleagues.

Our scientific activities started in the evening of October 8 with swath bathymetric and sediment echosounder profiling until we reached the focus area of investigations around midnight. A deep CTD station at 3000 m water depth provided first of all a

basis for the calibration of echosounders. Two subsequent stations of multicorer, bottom water sampler, and CTD were carried out on the way from the deformation front to the shallowest part of the region. With that we have crossed our entire study area, a segment of the Makran continental margin, and were prepared for the first geophysical survey: simultaneous profiling with TOBI and multichannel seismics. In order to do this, the streamer would have to be towed on the side of the vessel. Our first deployment was anticipated with some suspense, since during the 8-9 days allotted to profiling we hoped to acquire two valuable data sets at the same time. Thus first the seismic then the TOBI were put to water in the afternoon of October 9, a complex procedure rendered unproblematic by the excellent weather and glassy calm seas, and four days were spent on acquiring four profiles up and down the slope. Thus half of our planned survey work was completed by the morning of October 13 with an excellent dataset. In order to get a first overview, processing of the data started during acquisition; data quality was as impressive as the speed with which TOBI data were available for further planning. In the various datasets we found gas flares within the water column, high-backscatter patches at the seafloor, locations of gas accumulation in the shallow sediments, and active pathways along structural boundaries; all strong indications of ongoing seepage.

The following 4 days were spent with detailed investigations. During the weekend, the first complete sampling program within the OMZ was carried out. The CTD, the rosette, the bottom water sampler and the bottom boundary layer sampler were used within the water column, whereas in the sediment, the multicorer and the gravity corer were utilized. These activities were followed by two days of detailed studies above specific targets with the seismic and echosounder systems, providing a series of additional indications of seepage in the area. Several gas flares had been discovered in the backscatter data, where seismic images documented significant shallow gas accumulations, and finally, evidence of recent activity - bacterial mats and clam fields - were produced by the video sledge at two sites. In addition, a slump body was mapped in preparation for geotechnical sampling.

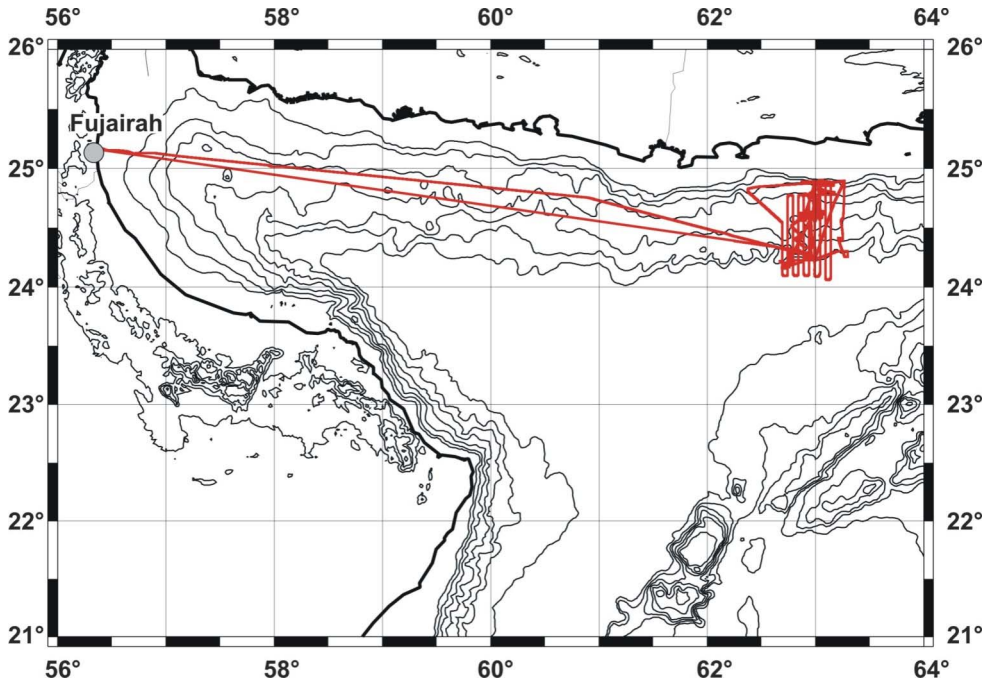
In the morning of October 17 we continued the simultaneous seismic and side scan sonar survey in the western part of our working area. Six north-south-oriented profiles were acquired in excellent weather conditions. Work concentrated on the deep water region, on the nascent ridge at the proto-deformation zone and the first and highest fully-developed diapiric ridge in specific. Promising indications in the TOBI data, including several gas flares beyond 3000 m water depth, suggested that this area would become an important location for the subsequent cruise leg.

After the recovery of seismic equipment and TOBI in the night from October 21 to 22 we steamed to shallower waters in order to continue the sampling work in the OMZ. Sampling of the water column and the sediment was carried out at two further stations, the first station in the morning of October 22nd in 350 m water depth, the next one two days later in 900 m. The stable weather conditions had caused the thermocline to intensify and move upwards. As this causes the mixed surface layer to thin and impedes nutrient input from depth, the result is a decreased phytoplankton production during the season. A low input of organic material into deeper water layers may explain their relatively low oxygen content that we measured within the OMZ. The OMZ in this region is about 800 - 900 m thick and oxygen concentrations are between 1 to 15 micromoles. Experiments to investigate specifically the anaerobic

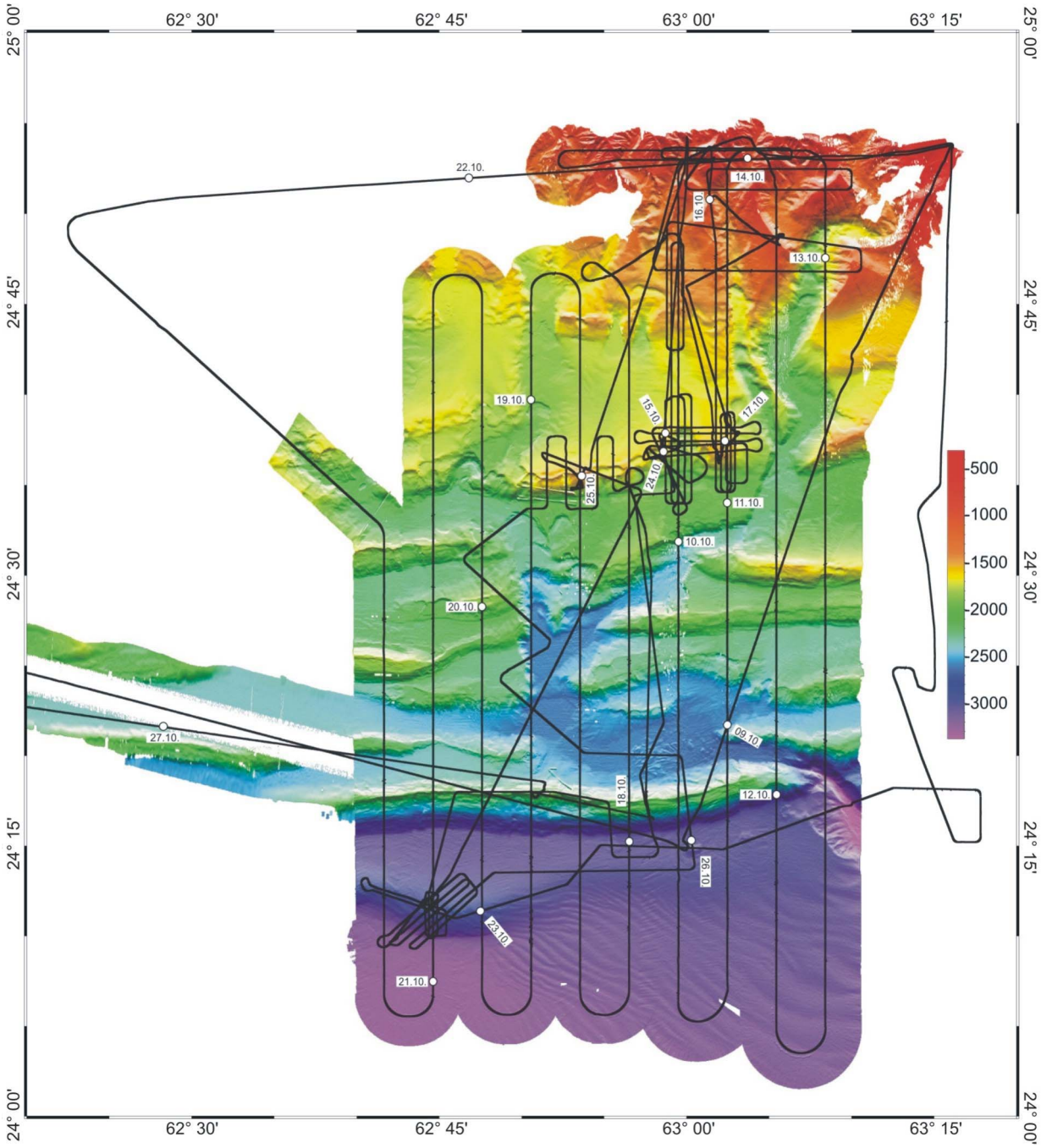
nitrogen turnover were started on the samples during the cruise, will however only be concluded in Bremen. Due to the anaerobic processes, OMZs are considered global nitrogen sinks, depriving phytoplankton in the oceans of an important nutrient.
An additional focus is measuring nutrient and methane concentration in the sediment and the water column. The transition zone between the two, the so-called bottom boundary layer (BBL), was studied with the help of two landers: the bottom water sampler and the BBL profiler. Elevated nutrient and particle concentrations were measured and the influence of these conditions upon the turnover processes is anticipated with suspense. Four gravity cores of 3 to 6 m length were taken on October 23 at a slump body.

Following the sampling work we continued the cruise by surveying potential seeps located in the TOBI data with detailed seismic and echosounder profiling as well as video observations. Although most of the working area has water depths in which methane forms gas hydrates, several gas flares (free gas bubbles in the water column) were discovered down to approximately 3000 m of water depths, the deepest site being in the vicinity of the most recent deformation front. A video track at this location documented extensive indications of gas venting as well as carbonates at another flare site in 1700 m water depth. Our scientific work ended in the night of October 26, allowing us to reach Fujairah in the morning of October 28, 2007.

During the cruise, systematic investigations have shown that intense deformation leads to gas ascent especially in the region of the diapiric ridges, locally penetrating even into the gas hydrate stability zone. These are also the locations where the near-surface anomalies were observed, producing a consistent scientific image. More than half a dozen of active seep structures were identified, and the simultaneous usage of TOBI and seismic allowed us a greatly improved geological interpretation and to separate shallow structures from those that are in connection with gas accumulations at depth.



Overview map of R/V METEOR track during cruise M74-2.



Track lines of R/V METEOR during cruise M74-2 (07.10. - 28.10. 2007.)